Software Architecture

Lecture 4

Event Systems

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previously
data flow and call-return styles

data flow
- batch sequential
- dataflow network (pipe & filter)
  - acyclic, fan-out, pipeline, Unix
- closed loop control

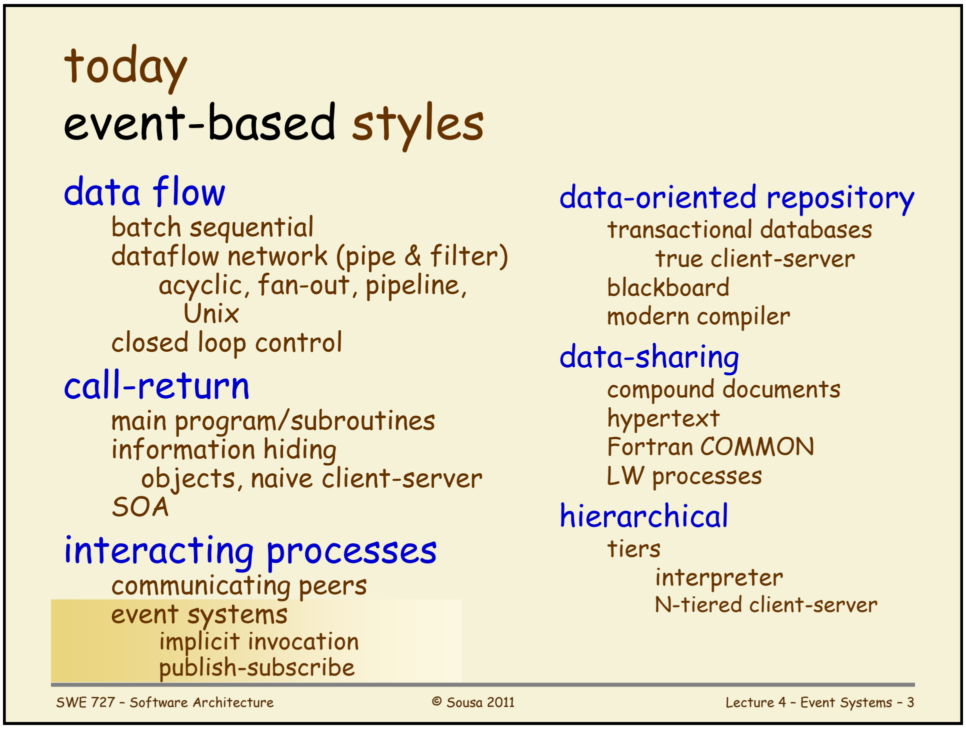
call-return
- main program/subroutines
- information hiding
  - objects, naive client-server
- SOA

interacting processes
- communicating peers
  - asynchronous messages
- event systems
  - implicit invocation
  - publish-subscribe

data-oriented repository
- transactional databases
  - true client-server
- blackboard
- modern compiler

data-sharing
- compound documents
- hypertext
- Fortran COMMON
- LW processes

hierarchical
- tiers
  - interpreter
  - N-tiered client-server



today
event-based styles

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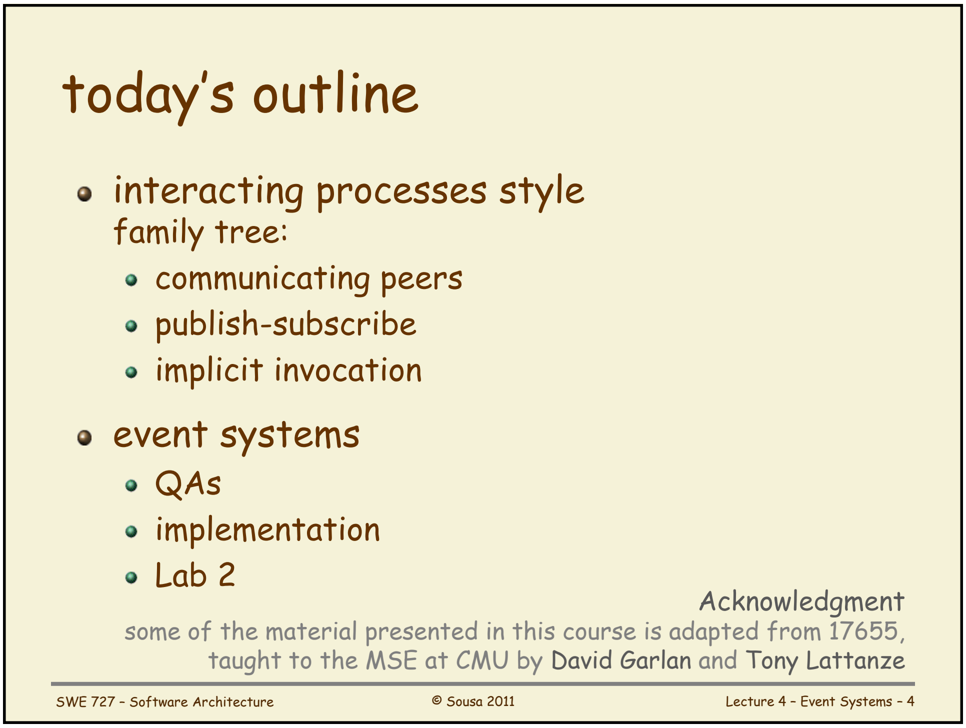


today's outline

- interacting processes style family tree:
  - communicating peers
  - publish-subscribe
  - implicit invocation
- event systems
  - QAs
  - implementation
  - Lab 2

Acknowledgment
some of the material presented in this course is adapted from 17655, taught to the MSE at CMU by David Garlan and Tony Lattanze

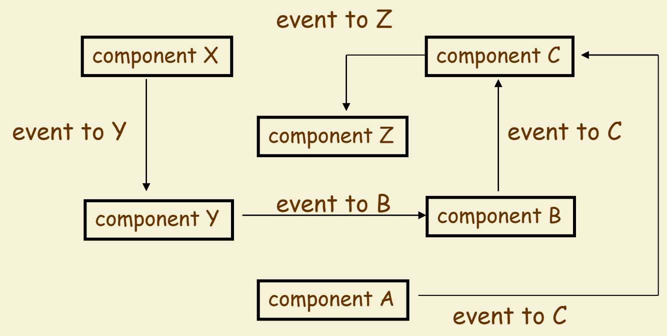
communication is loosely coupled in the interacting processes style

- components
  - independent threads of control
  - implemented as a process or thread
  - may be distributed
- connectors
  - communication is loosely coupled and often asynchronous
- system
  - components may or may not
    have knowledge of other components
  - functionality of one component does not depend upon others
  - overall system functionality depends upon all
    components functioning and communicating properly

interacting processes family tree

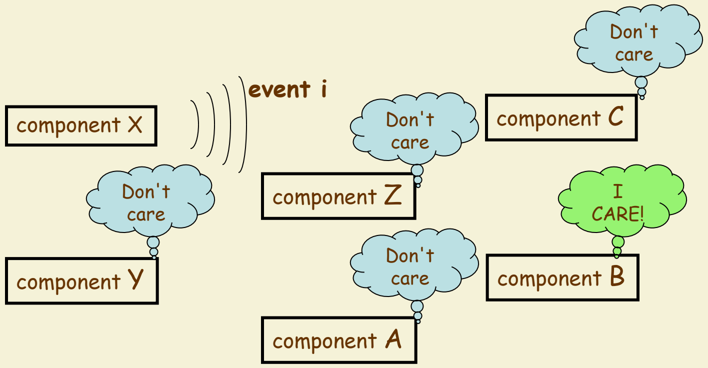
- communicating peers
  - asynchronous messages aka explicit events
    explicit wrt identifying the recipient
- event systems aka implicit events
  - events delivered to all interested components in some order
  - publish aka broadcast
  - publish-subscribe
    - interested components subscribe to events
    - interested components receive asynchronous message
  - implicit invocation
    - interested components register a callback method
    - upon the event, the method is invoked (call-return)

communicating peers
know recipient's identity



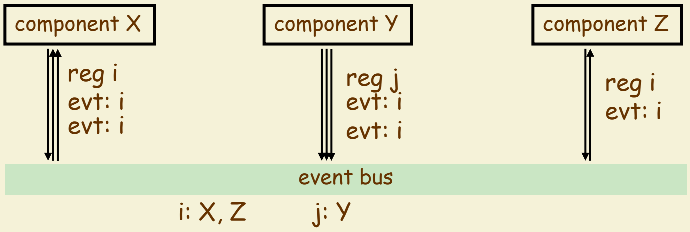
- identity of event recipients is known by event senders
- order of execution can be prescribed/predicted

event systems
publish aka broadcast



- Ethernet protocol in local area networks uses similar idea: event packet is tagged with recipient's address

publish-subscribe & implicit invocation rely on event infrastructure



- identity of event recipients is unknown to senders
- order of event delivery is unknown
  - different event buses make different guaranties or no guaranties about ordering

today's outline

- interacting processes style
- event systems
  - QAs
  - implementation
    - single process
    - distributed
  - Lab 2

many flavors
of event infrastructure

- C signals: OS (software) interrupts sent by *kill* function
  program can specify handler function for each signal
- Ada: defines *interrupts* and *interrupt handlers*
- C++: defines *events*, *event sources* and *event receivers*
- Visual Basic: widgets send various events depending upon user interaction, timers, and so forth; code attached to event is executed when event occurs
- Java *Observer* & *Observable* classes (more in a bit)
- database triggers: conditions associated to data
  trigger callbacks to registered methods
- middleware support for events: CORBA, etc.
- COTS event buses: JMS, IBM MQ Series, etc.

HLA example
high-end, large-scale simulation

- simulation is big business
  - hundreds of simulators, vendors
  - one training system for the Army cost $2 Billion alone
- problem: combine simulators into a joint "exercise"
  - may involve dozens or hundreds of simulators
  - usually highly distributed
  - produced by multiple vendors
- version 1.0 of the HLA published 1996
  - in 2000 HLA becomes IEEE Standard 1516
- HLA defines event-based standard for simulation
  - protocols for interaction
  - data modeling mechanisms
  - procedures to join and leave *federation* of simulations

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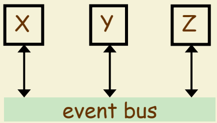
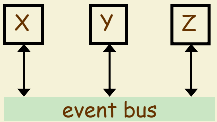
event systems



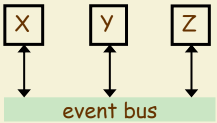
- promote scalability
  - easy to add new components
  - however, may increase overhead and hurt performance
- performance may be a challenge
  - hard to coordinate the order of processing
  - predicting and optimizing performance can be a challenge
  - specific performance measurements may still be good

event systems

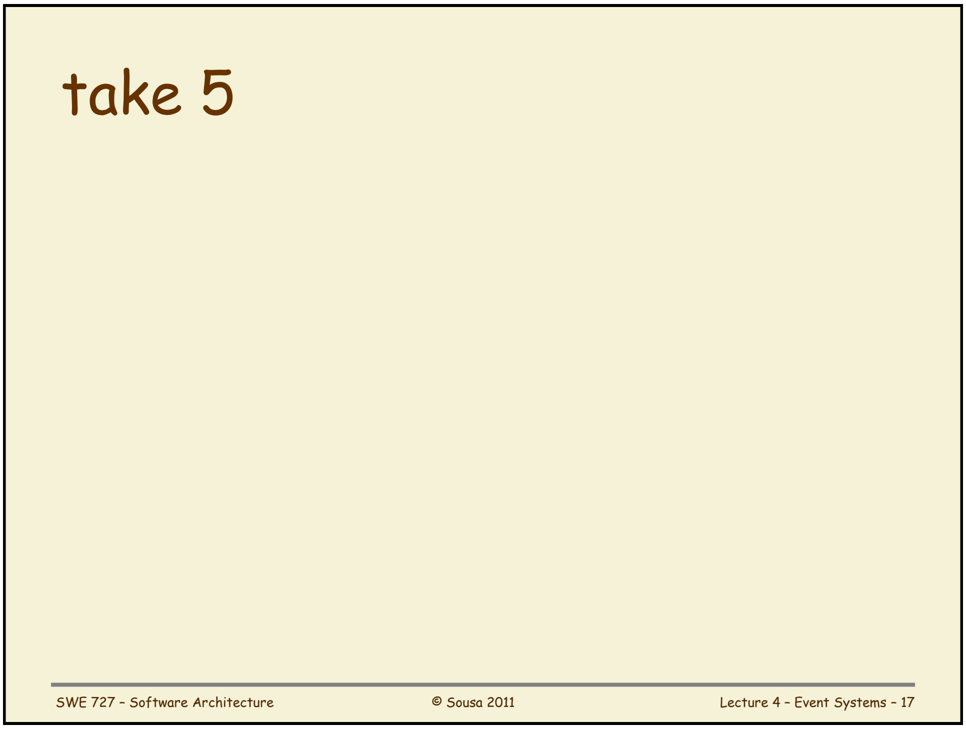


- promote reuse
  - decoupling: events offer an interface with little assumptions
  - announcers don't need to know the identity of responders
  - easy to reuse/register a component that communicates this way
- promote conceptual integrity
  - components work more independently
  - interaction policy can be cleanly separated from internals
  - however, due to non-determinism it may be hard to model and reason about run-time behavior

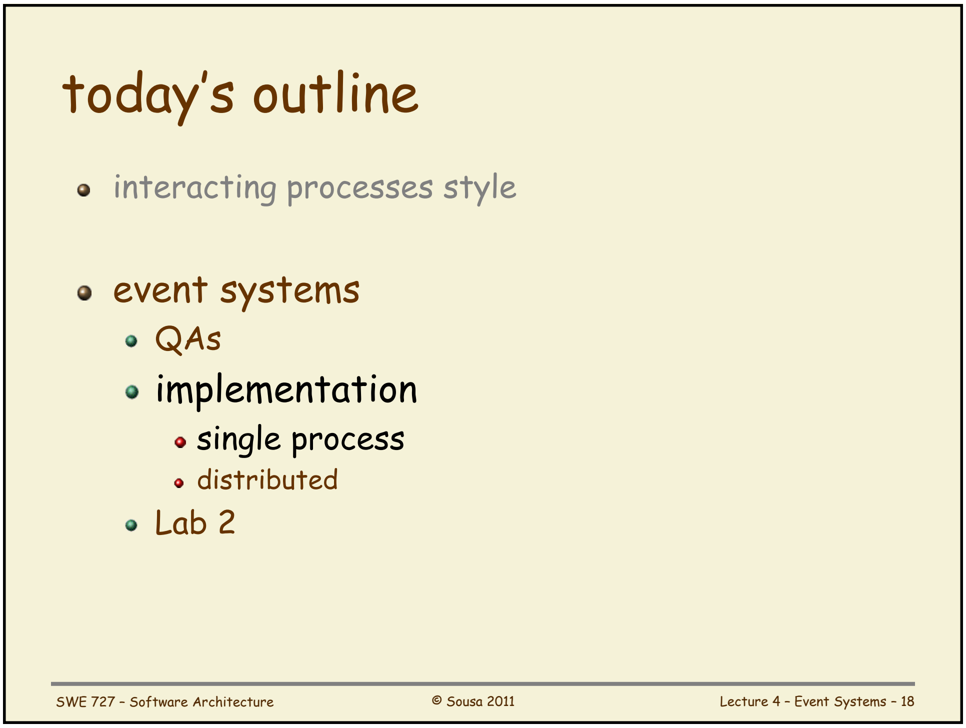
event systems



- promote maintainability
  - changes to one component have little or no effect on others
  - however, changes to when a component announces/register may impact system behavior
- testing may be a challenge
  - hard to trace origin/path of events
    - may require special tools and/or system structures to do so
  - hard to replicate ordering of actions
    - during testing & after deployment



take 5



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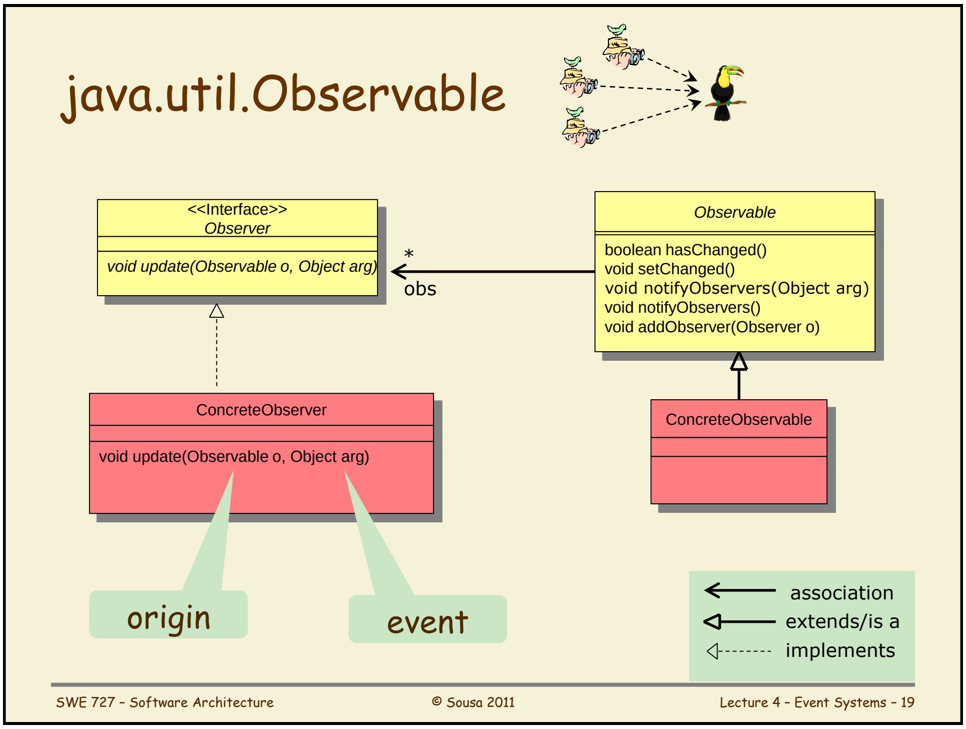


java.util.Observable

<<Interface>>
Observer

void update(Observable o, Object arg)

*
obs

Observable

boolean hasChanged()
void setChanged()
void notifyObservers(Object arg)
void notifyObservers()
void addObserver(Observer o)

ConcreteObserver

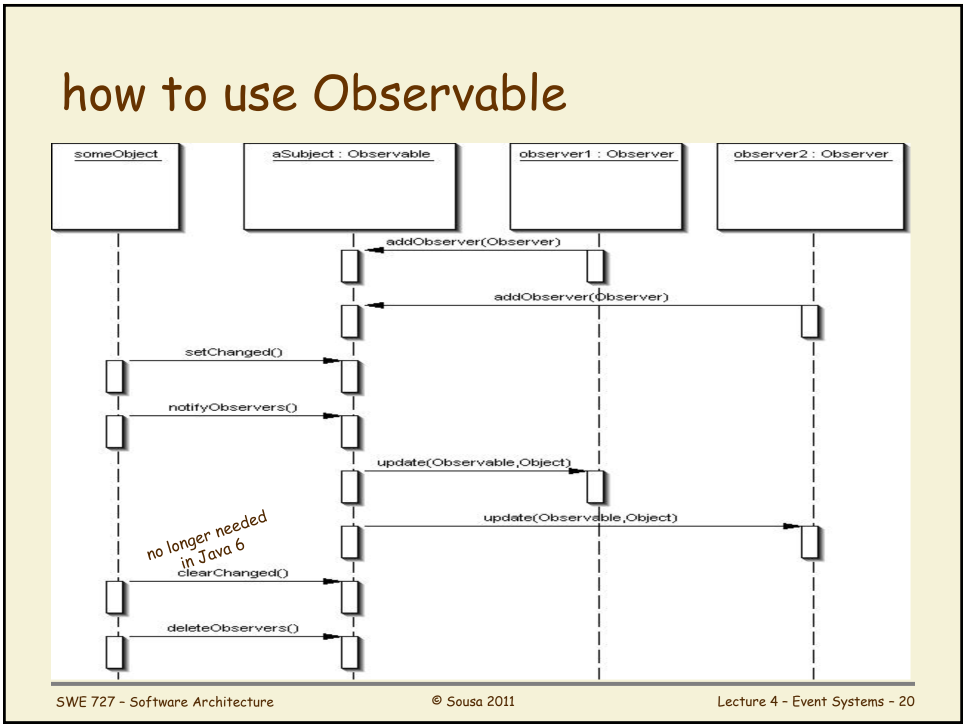
void update(Observable o, Object arg)

ConcreteObservable

origin

event

association
extends/is a
implements



how to use Observable

someObject
aSubject : Observable
observer1 : Observer
observer2 : Observer

addObserver(Observer)
addObserver(Observer)
setChanged()
notifyObservers()
update(Observable,Object)
update(Observable,Object)
no longer needed
in Java 6
clearChanged()
deleteObservers()

single process example
interactive student registration

- next class

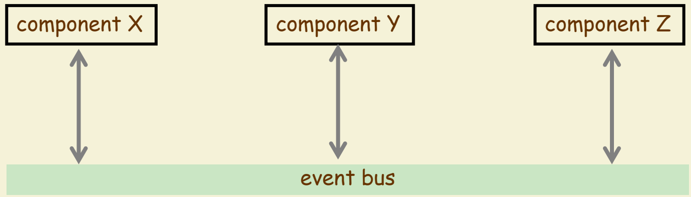
lab2: distributed event system
smart buildings

- as in Lab 1, you are given a working system
  - control temperature and humidity in a museum
    to preserve delicate paintings
- sensors
  - monitor *environment* and post periodic events
    temperature, smoke, motion, intrusion, humidity…
- controllers
  - monitor events and control *actuators*
    heaters, chillers, humidifiers, dehumidifiers, door locks…
- consoles
  - enable users to set temperature, humidity, enable security…

lab2: distributed event system
enhance system

- A: intrusion detection
  - window break, door break, motion
- B: fire protection
  - fire alarm switches, sprinklers
- C: maintenance console
  - list active systems

in summary, many event systems
rely on event infrastructure



component X

component Y

component Z

event bus

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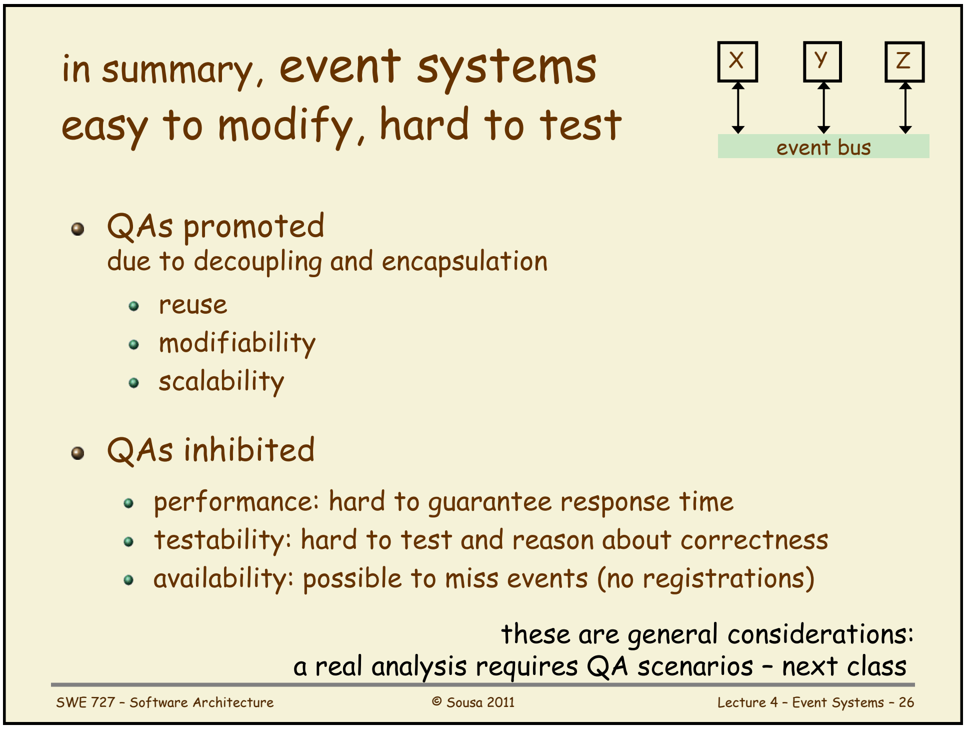

X
Y
Z
event bus

in summary, event systems easy to modify, hard to test

- QAs promoted
  due to decoupling and encapsulation
  - reuse
  - modifiability
  - scalability
- QAs inhibited
  - performance: hard to guarantee response time
  - testability: hard to test and reason about correctness
  - availability: possible to miss events (no registrations)

these are general considerations:
a real analysis requires QA scenarios – next class